## Consonant Classification

<table>
<thead>
<tr>
<th>Place of articulation</th>
<th>Bilabial</th>
<th>Labiodental</th>
<th>Interdental</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral stop voiced</td>
<td>p (pin)</td>
<td>b (ban)</td>
<td>t (tan)</td>
<td>k (kan)</td>
<td>g (gan)</td>
<td></td>
</tr>
<tr>
<td>Nasal stop voiced</td>
<td>m (nap)</td>
<td>n (nap)</td>
<td>n (nun)</td>
<td>g (gan)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricative voiced</td>
<td>f (fan)</td>
<td>v (van)</td>
<td>θ (than)</td>
<td>s (san)</td>
<td>z (zun)</td>
<td>Ы (yen)</td>
</tr>
<tr>
<td>Affricate voiced</td>
<td>j (jen)</td>
<td></td>
<td></td>
<td></td>
<td>ɾ (ran)</td>
<td></td>
</tr>
<tr>
<td>Liquid voiced</td>
<td>l (lan)</td>
<td>r (ran)</td>
<td>r (ran)</td>
<td>ɾ (ran)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glides voiced</td>
<td>j (jen)</td>
<td>w (we)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
International Phonetic Alphabet (consonants)

<table>
<thead>
<tr>
<th>CONSONANTS</th>
<th>Blaschke</th>
<th>Latinized</th>
<th>German</th>
<th>Arabic</th>
<th>Pseudo-</th>
<th>Palatal</th>
<th>Velar</th>
<th>Uductory</th>
<th>Phonemic</th>
<th>Greek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plosive</td>
<td>p b</td>
<td>t d</td>
<td>t d</td>
<td>c j k g</td>
<td>q g</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m m̃</td>
<td>n  ñ</td>
<td>n h ñ</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trill</td>
<td>b R</td>
<td>r R</td>
<td>r R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap or Flap</td>
<td>f t</td>
<td>r l</td>
<td>r l</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>φ β f v θ ð s z j 3 s z σ j x y χ h s h ń h ń</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Lateral Fricative</td>
<td>ʃ ç ʒ ʃ ʒ</td>
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</tr>
<tr>
<td>Appnasal</td>
<td>ŋ ŋ</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral Approximant</td>
<td>l l ʎ ʎ</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ejective stop</td>
<td>p' t' t' c' k' q'</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implosive</td>
<td>b d</td>
<td>t df</td>
<td>c f k g</td>
<td>q g</td>
<td>q' g'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where symbols appear in pairs, the one to the right represents a voiced consonant. Hyphens denote voiced and voiceless variants.

International Phonetic Alphabet (vowels)

<table>
<thead>
<tr>
<th>VOWELS</th>
<th>Front</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close</td>
<td>i Y</td>
<td>i u</td>
<td>u u</td>
</tr>
<tr>
<td>Close-mid</td>
<td>e ø</td>
<td></td>
<td>ø o</td>
</tr>
<tr>
<td>Open-mid</td>
<td>e ø e</td>
<td></td>
<td>ø ø</td>
</tr>
<tr>
<td>Open</td>
<td>a ø e</td>
<td></td>
<td>ø ø</td>
</tr>
</tbody>
</table>

Where symbols appear in pairs, the one to the right represents a rounded vowel.
Peter Ladefoged 1926-2006
http://www.linguistics.ucla.edu/people/ladefoge/
Loss of Categorical Perception

- Example: Hindi contrast

Perceptual Loss: Locus of Onset

- When does perceptual loss take place?
- Hindi contrasts tested on…
  - Hindi-speaking adults
    - Discrimination
  - English-speaking adults
    - No discrimination
  - English-exposed 7-month-olds
    (Werker, 1981)
    - Discrimination
Hindi (spoken in India): unvoiced unaspirated retroflex vs. dental stop

Dental Stop

Retroflex Stop

Retroflex - tongue curled so tip is behind alveolar ridge
Dental - tip of tongue on teeth
(English /t/ is somewhere between the two)

Conditioned Headturn Procedure

Conditioned Headturn Procedure

Reinforcer
Speaker
Camera

Infant
Parent
Assistant
Toys
In the conditioning procedure used by Kuhl (1983, 1989), infants are trained to turn their heads toward the loudspeaker on their left when they hear a change from one speech category to another.

Hindi (spoken in India):
unvoiced unaspirated retroflex vs. dental stop

Dental Stop

Retroflex Stop

Retroflex - tongue curled so tip is behind alveolar ridge
Dental - tip of tongue on teeth
(English /t/ is somewhere between the two)
Salish
(Native North American—Canadian—language): glotalized voiceless stops

Uvular

Velar

(note: they are actually ejectives - ejective is produced by obstructing the airflow by raising the back of the tongue against or behind the velum)

Velar - tongue is raised against velum
Uvular - tongue is raised behind the velum

Not-So-Special Perception

• Three main issues undermine the view that categorical perception makes speech special:
  – Some speech sounds do not evoke categorical perception (e.g., vowels)
  – It has been shown that musical sounds (non-speech sounds) of various kinds (e.g., notes, bowing, plucking) appear to have categorical properties
  – Non-linguistic animals have been shown to perceive speech sounds categorically as well
Language Processing

• Area ‘storing’ permanent information about word sounds (~Wernicke’s)
• Area for speech planning and programming (~Broca’s)
• Conceptual storage area

History of Broca’s Aphasia

• Paul Broca
  – Treating patient for leg infection; patient was an epileptic who only said “tan”
  – Found brain lesion in posterior portion of left inferior frontal gyrus
  – These sorts of patients generally showed right hemiparesis (weakness of right arm & leg)
Broca’s Summary

- Speech output is slow and effortful and lacks function words (like a telegram)
- Broca’s aphasics have a hard time understanding reversible sentences, where a full understanding of the sentence depends on syntactic assignment of thematic roles (e.g., the boy kicked the girl/the boy was kicked by the girl)
- Problems with speech articulation because of deficits in regulation of articulatory apparatus


History of Wernicke’s Aphasia

• Carl Wernicke (1870s)
  – Described patients with trouble understanding spoken language following stroke
  – Damage in posterior regions of superior temporal region of Heschl’s gyrus
  – Damage to this area produced poor language comprehension due to lost word-related memories and nonsense speech resulted from patients’ inability to monitor their own output
Wernicke’s Summary

- Wernicke’s aphasics speak fluently, but make no sense; their speech is meaningless
- They make many notable semantic errors
Language in the Brain

- Broca’s area concentrates on motor memory for words; Wernicke’s area is the region concerned with sensory memory for words
- These ideas led to a view of language in which 3 brain centers interact as foundations of language:
  - Production area
  - Comprehension area
  - Conceptual area
Lichtheim’s (1885) Model of Language Processing

• Arrows indicate direction that information flows
  (From this model it was predicted that lesions in the 3 main areas could account for 7 main aphasic syndromes; lesions indicated by line segments transecting connections between A, B, and M)

• “A” = area storing permanent information about word sounds (Wernicke’s)
• “M” = speech planning and programming area (Broca’s)
• “B” = conceptual storage

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Homunculus

– Different amounts of brain real estate are devoted to different parts of the body.
Homunculus

– Different amounts of brain real estate are devoted to different parts of the body.